Claims

1. A method of producing a micro-electromechanical element comprising the following steps:

a) structuring a first intermediate layer (4; 24), which is applied to a first main surface of a first semiconductor wafer (2; 26), so as to produce a recess (6; 20, 22, 30);

b) connecting the first semiconductor wafer (2; 26) via the first intermediate layer (4; 24) to a second semiconductor wafer (8; 28) in such a way that a hermetically sealed cavity (12; 20, 22, 30) is defined by the recess;

c) thinning one of the wafers (2; 26) from a surface facing away from said first intermediate layer so as to produce a diaphragm-like structure (14; 32, 36) on top of the cavity (12; 20, 22);

d) producing electronic components (16) in said thinned semiconductor wafer (2; 26);

characterized by the steps of

e) providing at least one further intermediate layer between the two semiconductor wafers (2, 8; 26, 28), which, prior to the connection of the two semiconductor wafers, is structured, in such a way that the structure formed in said at least one further inter-

mediate layer and the recess in said first intermediate layer define the cavity; and

f) producing at least one defined opening (36) so as to provide access to the hermetically sealed cavity (20, 22).

2. A method of producing a micro-electromechanical element comprising the following steps:

a) structuring a first intermediate layer (4; 24), which is applied to a first main surface of a first semiconductor wafer (2; 26), so as to produce a recess (6; 20, 22, 30);

b) connecting the first semiconductor wafer (2; 26) via the first intermediate layer (4; 24) to a second semiconductor wafer (8; 28) in such a way that a hermetically sealed cavity (12; 20, 22, 30) is defined by the recess;

c) thinning one of the wafers (2; 26) from a surface facing away from said first intermediate layer (4; 24) so as to produce a diaphragm-like structure (14; 32, 36) on top of the cavity (12; 20, 22); and

d) producing electronic components (16) in said thinned semiconductor wafer (2; 26);

characterized by the step of

e) dicing a plurality of micro-electromechanical structures, which are formed in a wafer according to

steps a) to d), so as to obtain chips, a defined opening (36), which provides access to the hermetically sealed cavities (20, 22), being produced by the dicing step.

3. A method of producing a micro-electromechanical element comprising the following steps:

a) structuring a first intermediate layer (24), which is applied to a first main surface of a first semiconductor wafer (26), so as to produce a recess (20, 22, 30);

b) connecting the first semiconductor wafer (26) via the first intermediate layer (24) to a second semiconductor wafer (28) in such a way that a hermetically sealed cavity (20, 22, 30) is defined by the recess;

c) thinning one of the wafers (26) from a surface facing away from said first intermediate layer (24) so as to produce a diaphragm-like structure (14; 32, 36) on top of the cavity (20, 22);

d) producing electronic components (16) in said thinned semiconductor wafer (26);

characterized in that

in step a) the intermediate layer is structured in such a way that, when the two wafers (26, 28) have been connected, at least two hermetically sealed cavities (20, 22) are defined, which are intercon-

nected by a channel (30), a respective diaphragm-like structure (32, 34) being arranged on top of each of said cavities (20, 22) after step c),

and that the method additionally comprises the step e) of opening a defined opening (36) through the diaphragm-like structure (34) on top of one of the cavities (22).

4. A method of producing a micro-electromechanical element comprising the following steps:

a) structuring a first intermediate layer (4; 24), which is applied to a first main surface of a first semiconductor wafer (2; 26), so as to produce a recess (6; 20, 22, 30);

b) connecting the first semiconductor wafer (2; 26) via the first intermediate layer (4; 24) to a second semiconductor wafer (8; 28) in such a way that a hermetically sealed cavity (12; 20, 22, 30) is defined by the recess;

c) thinning one of the wafers (2; 26) from a surface facing away from said first intermediate layer (4; 24) so as to produce a diaphragm-like structure (14; 32, 36) on top of the cavity (12; 20, 22); and

d) producing electronic components (16) in said thinned semiconductor wafer (2; 26);

characterized by the step of

e) producing a plurality of defined openings in the diaphragm-like structure in such a way that, when said openings have been produced, the diaphragm-like structure forms a supporting structure for the movable mass of an acceleration sensor.

5. A method according to one of the claims 1 to 4, wherein the main surface of the second semiconductor wafer (8), which is connected to the first semiconductor wafer (2) via the intermediate layer (4), has applied thereto a second intermediate layer (10) prior to the connecting step.

6. A method according to claim 5, wherein the second intermediate layer is structured in such a way that, after the connecting step, the structure formed in the second intermediate layer and the recess in the first intermediate layer define the cavity.

7. A method according to one of the claims 1 to 6, wherein a cavity with areas of variable height is produced due to the use of a plurality of intermediate layers.

8. A method according to one of the claims 1 to 7, wherein the first and the second wafer (2, 8; 26, 28) consist of silicon.

9. A method according to one of the claims 1 to 8, wherein said intermediate layers consist of an oxide, a polysilicon, a nitride or of metal.

10. A method according to one of the claims 1 to 9, wherein said intermediate layers (24) are structured in such a

way that, after the connection of the two wafers (26, 28), a plurality of cavities (20, 22) is defined, said cavities being interconnected by channels (30) and hermetically sealed from their surroundings.

11. A method according to one of the claims 1 to 10, wherein the connection in step b) is carried out in a vacuum.

12. A method according to one of the claims 1 to 11, wherein an SOI wafer is used as a first (2; 26) and/or second (8; 28) wafer.

13. A method according to one of the claims 1 to 12, wherein said at least one defined opening (36) is produced in the diaphragm-like structure (34).

14. A method according to claim 13, wherein said at least one defined opening (36) is produced in the diaphragm-like structure (34) by means of a needle, a blade, by the use of a pulsed laser radiation or by etching.

15. A method according to claim 3, wherein the channel (30) is structured in the fashion of a labyrinth in step a) in such a way that disturbing products formed during the production of the opening are prevented from passing said channel.

Claims

1. A method of producing a micro-electromechanical element comprising the following steps:

a) structuring a first intermediate layer (4; 24), which is applied to a first main surface of a first semiconductor wafer (2; 26), so as to produce a recess (6; 20, 22, 30);

b) connecting the first semiconductor wafer (2; 26) via the first intermediate layer (4; 24) to a second semiconductor wafer (8; 28) in such a way that a hermetically sealed cavity (12; 20, 22, 30) is defined by the recess;

c) thinning one of the wafers (2; 26) from a surface facing away from said first intermediate layer (4; 24) so as to produce a diaphragm-like structure (14; 32, 36) on top of the cavity (12; 20, 22);

d) producing electronic components (16) in said thinned semiconductor wafer (2; 26);

e) producing at least one defined opening (36) so as to provide access to the hermetically sealed cavity (20, 22).

2. A method according to claim 1, wherein the main surface of the second semiconductor wafer (8), which is connected to the first semiconductor wafer (2) via the in-

termediate layer (4), has applied thereto a second intermediate layer (10) prior to the connecting step.

3. A method according to claim 2, wherein the second intermediate layer is structured in such a way that, after the connecting step, the structure formed in the second intermediate layer and the recess in the first intermediate layer define the cavity.

4. A method according to one of the claims 1 to 3, wherein, in addition to the first intermediate layer, further intermediate layers are provided between the two semiconductor wafers, said intermediate layers being structured before the two semiconductor wafers are connected, so as to produce a cavity with areas of variable height.

5. A method according to one of the claims 1 to 4, wherein the first and the second wafer (2, 8; 26, 28) consist of silicon.

6. A method according to one of the claims 1 to 5, wherein said one or said plurality of intermediate layers consist(s) of an oxide, a polysilicon, a nitride or of metal.

7. A method according to one of the claims 1 to 6, wherein said one or said plurality of intermediate layers (24) are structured in such a way that, after the connection of the two wafers (26, 28), a plurality of cavities (20, 22) is defined, said cavities being interconnected by channels (30) and hermetically sealed from their surroundings.

8. A method according to one of the claims 1 to 7, wherein the connection in step b) is carried out in a vacuum.

9. A method according to one of the claims 1 to 11, wherein an SOI wafer is used as a first (2; 26) and/or second (8; 28) wafer.

10. A method according to one of the claims 1 to 9, wherein said at least one defined opening (36) is produced in the diaphragm-like structure (34).

11. A method according to claim 10, wherein said at least one defined opening (36) is produced in the diaphragm-like structure (34) by means of a needle, a blade, by the use of a pulsed laser radiation or by etching.

12. A method according to one of the claims 1 to 9, wherein a plurality of micro-electromechanical structures is produced in a wafer, said method comprising in addition the step of dicing the individual micromechanical structures so as to obtain chips, said at least one defined opening, which provides access to the hermetically sealed cavity, being produced by the dicing step.

13. A method according to one of the claims 1 to 12, wherein said one or said plurality of intermediate layers (24) is/are structured in step a) in such a way that, after the connection of the two wafers (26, 28), at least two hermetically sealed cavities (20, 22) interconnected by a channel (30) are defined, a diaphragm-like structure (32, 34) being arranged on top of each of said cavities (20, 22) after step c), and a defined opening (36)

through said diaphragm-like structure (34) of one of the cavities (22) being produced in step e).

14. A method according to claim 13, wherein the channel is structured in the fashion of a labyrinth in step a) in such a way that disturbing products formed during the production of the opening are prevented from passing said channel.

15. A method according to one of the claims 1 to 12, wherein a plurality of defined openings is produced in the diaphragm-like structure in step e) in such a way that, after the production of the openings, the diaphragm-like structure forms a supporting structure for the movable mass of an acceleration sensor.

as a rinsing liquid, which may penetrate into open cavities thus aggravating the particle and contamination problem.

It is additionally known to produce diaphragm-like structures making use of KOH back etching, when the electronic components on the front surface of a wafer have been finished. Due to the oblique etch edges occurring in the case of KOH etching, the integration level will, however, decrease substantially when this method is used, especially when a high number of micro-electromechanical components is produced from one wafer.

Various methods of producing semiconductor pressure sensors are additionally described in DE 3743080 A1.

It is the object of the present invention to provide a method of producing a micro-electromechanical element, which permits the use of conventional standard semiconductor production processes for producing electronic components in the wafer in which micromechanical elements are formed as well, the method permitting the production of micro-electromechanical elements with a high yield.

This object is achieved by a method of producing a micro-electromechanical element according to claim 1.

The present invention provides a method of producing a micro-electromechanical element in the case of which a first intermediate layer, which is applied to a first main surface of a first semiconductor wafer, is structured in a first step so as to produce a recess. The first semiconductor wafer is then connected via the first intermediate layer to a second semiconductor wafer in such a way that a hermetically sealed cavity is defined by the recess. Subsequently, one of the